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בקשה לפטנט
Application for Patent
212/01711

אני, (שם המבקש, מענו – ולגבי גוף מאוגד – מקום התאגדותו)
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בעל אמצאה מכח הדין Law ששמה הוא
Owner, by virtue of Law of an invention, the title of which is

(בעברית) (Hebrew) הזרמת מדיה

(באנגלית) (English) Media Streaming

מבקש בזאת כי ינתן לי עליה פטנט
hereby apply for a patent to be granted to me in respect thereof.

* בקשת חלוקה – Application of Division	* בקשת פטנט מוסף – Application for Patent Addition	* דרישה דין קדימה Priority Claim		
מבקשת פטנט from Application	* לבקשה/לפטנט to Patent/Appl.	מספר/סימן Number/Mark	תאריך Date	מדינת האגוד Convention Country
No. ____ מס'	No. ____ מס'			
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* יפוי כח: כללי/מיוחד – רצוף בזה / עוד יוגש
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212/01711

הזרמת מדיה

Media Streaming

בנדוויז בע"מ

Bandwiz Ltd.
c:212/01711

MEDIA STREAMING

FIELD OF THE INVENTION

The present invention is related to the transmission of stream information over a communication channel.

BACKGROUND

Many media types are typically provided in a streaming mode, for example movies and audio. An advantage of streaming is that there is substantially no delay at a receiver before the media can be previewed, providing the media stream is sent in a manner synchronized to the viewing. If a user is required to wait for a media stream to repeat itself, for example in a carousel transmission system, the delay is as long as the transmission repeat time.

Another type of media dissemination method is multicasting, which maybe combined with streaming. A single copy of the media stream is broadcast to a plurality of receivers. In some implementations, a complete file is transmitted by multicasting, without streaming, or is repeatedly transmitted.

Another type of data dissemination method is "on-demand" transmission. The transmission of data is synchronized with a request by a user. This type of dissemination is usually provided by unicasting (point to point connection). Alternatively, a receiver can select a start time, out of a small number of available times, at each of which times a complete retransmission of the data is performed. A particular application of "on-demand" dissemination is cable broadcasting of movies. In some implementations, a complete file may be transmitted "on-demand", for viewing when convenient. In such a file transmission system, if a media file size is FS and an available transmission bandwidth is TB, a minimally expected delay before the file can be played back is FS/TB.

SUMMARY OF THE INVENTION

An aspect of some embodiments of the invention relates to a media transmission method in which a desired tradeoff can be achieved between an expected delay and an available transmission bandwidth, for example in a streaming system. In an exemplary embodiment of the invention, no feedback from the receiver is required for synchronizing the transmission.

In some exemplary embodiments of the invention, later blocks of a file are transmitted and/or multicast at a lower data transmission rate (e.g., average number of bytes from that block per second) than earlier blocks, thus allowing the beginning of the file to be received sooner. In an exemplary embodiment of the invention, the later blocks are received and/or

processed, during the reception and playback of the earlier blocks. Thus, a lower transmission rate can be tolerated, since a longer reception time is available.

Optionally, the relative rates of block transmission are selected to take into account the total bandwidth, so that a continuous playback is possible, possibly while minimizing an expected startup delay. In an exemplary embodiment of the invention, the file is divided up into equal size blocks, each transmitted at a different rate. Alternatively or additionally, the file is divided up into different sized blocks, which are each transmitted using a same bandwidth and thus different blocks take different amounts of time to transmit. Intermediate embodiments, such as different size blocks at different data and/or block rates, are also possible.

In an exemplary embodiment of the invention, the media transmission method includes segmenting a media file into N blocks of unequal sizes. Optionally, the sizes of the blocks are of increasing size, each block being larger by a factor than a previous block, i.e., the blocks have an exponentially increasing size. Optionally, the factor is two. Thus, for example, a 15MB file can be divided into a 1MB block, a 2MB block, a 4MB block and a 8MB block. Each of these blocks (optionally encoded and/or sent as packets) is repeatedly transmitted on a separate channel. Optionally, the data rate of transmissions is the same or smaller than that required for real-time playback of the file. At a receiver a plurality of file blocks are received in parallel, such that packets from one block are received before all the packets for another block are received. The expected delay time is the time required to receive the smallest part. While the smallest part is being received and played, a second larger part can be received, and so, the effect is that of streamed playback. In some embodiments, the expected delay can be even shorter than the time for receiving a smallest block, for example using preferential encoding as described below.

In an exemplary embodiment of the invention, the expected delay goes down exponentially as a function of the provided bandwidth, rather than linearly, as might otherwise be expected.

In an exemplary embodiment of the invention, the above media transmission method is used for multicasting on a communication network, for example a cable network, a satellite network, a cellular telephone network or other types of wired and/or wireless transmission networks. Alternatively or additionally, this transmission method is used for unicasting, for example if synchronization between a source and a receiver are difficult and a streaming effect with a short expected delay is desired.

Optionally, the transmission is a packet based transmission. Alternatively or additionally, a FEC (forward error correction code) is used, so that a stream can be reconstructed from any set of received transmissions.

Alternatively or additionally, such an error-correction code is used to allow a slower playback, especially by receivers having a limitation on the number of channels they can receive at a time. Thus, in some embodiments of the invention, either the transmitter or the receiver may be limited to sending or receiving fewer than a desired number of streams in parallel. In some embodiments of the invention, a plurality of independent transmitters are provided, each transmitting its own stream(s), such that the combination of streams yields a viable data packet.

In an equal-block size embodiment, the blocks for a file are encoded into packets, with packets for the beginning if the file sent out at a higher rate than packets for the end of the file. A harmonic series may be used to define the relative transmission rate, as a function of file position. The packets may be sent on a single or a plurality of channels.

In some embodiments of the invention, a file is transmitted in a manner that supports at least one starting point (e.g., an entry point) other than the file beginning. Different entry points may have same or different expected delays. In an exemplary embodiment of the invention, a plurality of entry points is provided by using a non-monotonic function to describe the block sizes, block transmission rates and/or other data-preferential transmission methods described herein. Thus, the packet relating to the entry points are more likely to be received fast and a smaller expected delay is thus achieved for those points.

There is thus provided in accordance with an exemplary embodiment of the invention, a method of transmitting a data over a communication medium, comprising:

determining relative desired reconstruction times for different parts of the file;

differentially allocating different transmission rates for the different parts of the base responsive to said determining; and

transmitting the file in sections, at said different transmission rates. Optionally, said determining comprises determining a continuous of times representing a continuous play-back of said file. Alternatively or additionally, said transmitting comprises multicasting. Alternatively or additionally, said transmitting comprises transmitting different sections using different transmission channels. Alternatively or additionally, said transmitting comprises said different sections at different packet transmission rates. Alternatively or additionally, said sections are different sizes. Alternatively or additionally, said different transmission rates are

selected such that a receiver can reconstruct and play one section in the time it takes the receiver to receive a next section. Alternatively or additionally, said file comprises a media file in an on-demand system. Alternatively or additionally, transmitting comprises encoding said sections using an FEC (forward error correction) code having the property that a data section can be reconstructed from substantially any N packets received that relate to that data section.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic illustration of a data streaming configuration, in accordance with an exemplary embodiment of the invention.

Fig. 2 is a schematic illustration of a file split up for transmission in accordance with an exemplary embodiment of the invention; and

Fig. 3 is a flowchart of a method of reconstructing a transmitted data file, transmitted by streaming in accordance with an exemplary embodiment of the invention.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

Fig. 1 is a schematic illustration of a data streaming configuration 100, in accordance with an exemplary embodiment of the invention. One or more transmitters 102 transmit a file as a plurality of streams of data or data packets. In some embodiments of the invention, each such stream is multicast. Alternatively or additionally, each stream is repeatedly transmitted, for example using a data carousel or a forward error correction code, as will be described in more detail below.

One or more receivers 104 receive the data streams and reconstruct a copy of the transmitted file. An optional distribution controller 106 is described below.

Fig. 2 is a schematic illustration of a file 200 split up for transmission in accordance with an exemplary embodiment of the invention. As shown in Fig. 2 file 200 is split into blocks 202, 204, 206, 208, 210 and 212, which are not all the same size. In an exemplary embodiment of the invention, each part of the file is larger by a factor than a previous part, for example a factor of two. The last block may or may not fit this criterion, for example including only a residual portion of file 200. As will be described below, the size of the factor may depend, inter alia, on the ratio between transmission speed and playback. The factor can be lower than or higher than two.

The number of blocks into which file 200 is divided may be determined, for example, by the number of parallel streams available or the ability of the receivers to receive parallel streams. In some embodiments of the invention, as the number of blocks increases, the expected delay before the file can be played back is smaller. In some embodiments of the

invention; the expected delay time can be as short as $DT = \frac{FS}{e^{nBW} - 1}$, where DT is the delay time, FS is the file size and nBW is the ratio between the total available bandwidth and the bandwidth required for real-time playback. It is noted that smooth playback is also possible in some cases where the total available bandwidth is smaller than the play-back bandwidth. In some embodiments of the invention, the relationship between the number of blocks, BK, and delay time is $DT = \frac{FS}{(1 + nBW / BK)^{BK} - 1}$. Thus, as the blocks are made smaller (relative to the number of streams), the expected delay approaches an "e" base exponent. In some applications, a base of at least 2 or even 2.25 is achieved. Although the relationship between bandwidth and delay is exponential, by properly selecting the block sizes (and/or transmission rates) other relationship, such as quadric or higher power, can be achieved.

Fig. 3 is a flowchart 300 of a method of reconstructing a transmitted data file, transmitted by streaming in accordance with an exemplary embodiment of the invention. At 302, a plurality of K (preferably K=N) of the available N blocks are received in parallel. At 304, if an ith block is received, it is displayed (306), while continuing to receive the other blocks in parallel. Generally, as the blocks are in ascending order, the blocks will also complete reception in order. If a block is missing, some frames may be skipped, or the playback delayed until the required blocks are received. By selecting a factor of two between block sizes and assuming a real-time transmission rate for each stream, the following effect is achieved: the time that it takes to receive and display a block is the same as the time it takes to receive the next block. Thus, when the display of a first block is completed, the consecutive block is now ready for display.

In some embodiments of the invention, the size of the smallest block is selected to achieve a desired expected delay. Alternatively or additionally, the block size(s) are selected in conformance with transmission channel limitations and/or limitations on the availability of multicast address names.

In some embodiments of the invention, the blocks are sent as consecutive bits, possibly arranged in packets. In each stream, the bits are repeatedly sent. However, if any bits are missed, a complete cycle must be waited. Also, in a streaming mode, a minimum expected delay is the time to receive a complete cycle.

Alternatively, the data is sent using an FEC (forward error correction) code, in which a message of N bits can be reconstructed if any N bits (possibly plus a small overhead) are

received. Data can begin to be usefully accumulated from the very first received bit. Also, if any bits are lost, the following bits can replace them. Exemplary FECs are described for example in Internet draft numbers draft-ietf-rmt-bb-fec-01, and draft-ietf-rmt-pi-alc-01 both of 14 July 2000, the disclosures of which are incorporated herein by reference.

In an exemplary encoding scheme, in accordance with one embodiment of the invention, a data packet is generated by XORing together a plurality of data sections from the file (each data section is possibly the size of a channel block, while the division into blocks described above, can be unrelated). The selection of data sections to use in each packet, can depend, for example, on the location of the section relative to the start of the file. In an exemplary embodiment of the invention, the percentage of data sections used for a packet in a particular file section (described below) or file block is smaller than 50%, for example, being less than 10%, 20% or 30%.

In an exemplary decoding method, a set of equations is solved, using the received packets as input. A random number generation seed may be provided with each packet, to indicate which data sections of the original files take part in the packet. In an exemplary embodiment of the invention, the file is divided into sections, and separate packets generated for each section. These sections may overlap the file blocks or may be considerably smaller. Possibly, packets from earlier sections, may be sent at a higher rate than packets from later sections and/or the section sizes may vary along the file. In an exemplary embodiment of the invention, cross-section packets are also provided and combine data between different sections. Such packets are useful in that they allow to propagate the reconstruction of file section into another file section, even if some packets are missing from the other section. In the streaming implementations, such packets may assist in providing a limited look-ahead ability and/or compensate for missing packets. In an exemplary embodiment of the invention, the cross-section packets are limited to file sections that have similar ordinal numbers.

The above method is especially useful for files that are viewed starting at their beginning. For files with multiple entry points, the file may be treated as a plurality of sub files, each with its own starting point having its own expected delay.

Alternatively or additionally to varying block sizes in order to achieve preferential reception of earlier blocks of the file, same size block sizes may be used, with higher transmission rates of packets from the earlier blocks of the file. For example, by sending packets relating to earlier blocks more often than packets relating to later blocks. Thus, sufficient packets to reconstruct a first block of the file will generally be received sooner than

packets required for reconstructing the latter part of the file. The expected delay indicates the expected amount of time to accumulate sufficient packets. The above block size factor is translated, in this embodiment, into a relative packet transmission rate. Alternatively or additionally, a combined measure of packet transmission rate and relative block size can be used, to control the relative temporal availability (at the receiver) of different parts of the file. Alternatively or additionally, preferential encoding schemes, in which one part of the file takes part in more packets than other parts of the file, may also be used.

Multiple entry points can be provided by varying the packet transmission rate over the file, for example providing greater transmission rates at the desired entry points. Alternatively or additionally, to controlling packet transmission rates, other preferential encoding schemes can be used, for example using earlier blocks of the file in a greater percentage of the packets.

In some embodiments of the invention, when a user stops viewing a media file, the last block and the previously received by un-displayed blocks are saved, so that continued viewing of the file can resume with a short or substantially no delay. Alternatively or additionally, a user may use the previously received packets for a playback function. Optionally, for points in the file where playback is expected, the file structure is inverted in time, with earlier blocks being short and/or transmitted more often, so that playback can be rapid. Alternatively or additionally, packets received and relating to later blocks of the file, may be used for a limited preview, for example of a small number of frames.

The above described methods may require a memory to store very large files. By splitting file 200 into multiple parts, each of which is processed and transmitted as above in series (expect for the first block, whose transmission overlaps with a previous part), these memory requirements may be reduced.

Various other parameters of the above described methods can be traded-off. In one example, the receiver can only receive two channels at a time. By delaying longer than the expected delay time before starting, the receiver can expect to have enough information for continuous display at any time.

In an exemplary application, a receiver may receive K channels, with a total bandwidth of nBW times the bandwidth needed for real-time play-back. Such a receiver may be expected to store, in parallel, to a plurality of storage streams, and may require a memory buffer for each stream, to make a disk access more efficient. Such a device (or transmission channel) may be limited, for example, in total bandwidth availability, disk size, memory, and number of streams that can be listened to in parallel. In some embodiments of the invention, if the

number of received streams is smaller than the number of transmitted streams, the receiver receives as many streams as it can in parallel, and as one block is received, disconnects that stream and connects to and starts receiving packets from the next stream.

In an exemplary embodiment of the invention, some overhead time is provided for each received block to be reconstructed, thus allowing a non-ideal CPU to be used. Alternatively or additionally, the received blocks are decoded continuously, preventing CPU load peaks.

In another exemplary tradeoff, if the reception time is slower than real-time playback, for a particular channel, the relative size factor is made smaller than 2. Alternatively or additionally, if the reception time is faster than real-time, the relative size factor is made greater than 2. It should be noted that in some embodiments of the invention, fairly short delays are achieved even though each streaming channel is the same speed or slower than the playback speed.

In some applications, two or more of the streaming channels may be mixed into a single channel. Alternatively or additionally, some transmission channels may be faster than others (in practice). Optionally, the number of blocks, the size of the blocks and/or the relative size factors are dependent on the relative speed of the various channels. Possibly, the channel rates are monitored in real-time and the size of blocks modified accordingly, for example using distribution controller 106. In particular, the method of differential transmission rates for different parts of the file may be usefully applied using a single channel multicasting, in which packets relating to different parts of the file are selected for transmission at different relative rate.

In some exemplary embodiments of the invention, the blocks do not overlap. Alternatively, there is at least some overlap between the blocks into which the file is divided. Alternatively or additionally, at least some of the bits in the file are encoded to have a higher probability of being decoded sooner than the rest of the file. This can allow beginning playback of the next block even before it is all received.

Referring back to Fig. 1, a distribution controller 106 may be provided to decide which data files are streamed and/or multicast and/or what expected delay to offer. Such a controller may base its actions, for example, on request and/or responses from receivers 104 and/or channel limitations. Controller 106 may also be used to allow receivers 104 to respond to the received data, for example, emulating an interactive HTTP connection.

In a particular example of cable television, a 128 minute movie may be provided with an expected delay of no more than 0.5 minutes, by broadcasting the movie on 8 regular channels, as described above. In a standard video on demand transmission method, where each channel transmits the whole movie, at a different start time, the expected delay is 16 minutes. The parallel-received blocks may be stored, for example, using a TiVo (or other television transmission recorder). Such broadcasting could also take advantage of methods known in the art for targeting only parts of the cable network. Alternatively or additionally, the multicasting is received at network nodes and then re-broadcast as needed. Although FEC coding may be used, in some embodiments of the invention, dropped frames may not be a problem and no coding is used. In some implementations, the data is encrypted and/or compressed prior to transmission.

In another exemplary embodiment, the communication network is a satellite, which typically has associated delay and link problems of sending a request for a specific media file.

In another example embodiment, the communication network is the Internet, where, for example, a movie server may desire to maintain constant data transmission rates, without being required to respond to requests by starting to send a same movie at multiple times. In some cases, when multiple request arrive, additional channels are allocated to the movie, significantly reducing the expected delay time.

In another exemplary embodiment, the communication network is a cellular telephone network or a radio network, where a user may desire to flip between channels, and always start at a beginning of a presentation item.

Although a packet based transmission network may be used, the above method can also be applied to other types of networks, including both synchronous and asynchronous networks and packet based, switching based and/or continuous transmission networks. Also, the above method may be applied to both digital and analog communications.

In some of the above embodiments, the transmitter transmits an index of the channels and their mapping into media presentations. In some embodiments, controller 106, as described above, may use responses to this index, to decide which files to broadcast, at what rate, how many and which entry points and/or how many sections to divide the file into.

In some embodiments of the invention, a receiver (e.g., a television, set top box or a computer) may record packets from a plurality of channels, thus allowing a rapid transition between a first channel and other channels. Alternatively or additionally, an exemplary

channel may include some packets relating to other channels, for example channels of rélated content and/or language.

A feature of some types of broadcast channels is that their contents change only slowly over time. For example, news channels often continuously transmit a same content, while changing a small number of news items, every so often.

In an exemplary embodiment of the invention, a differential decoding ability is used to selectively receive and decode only enough packets for displaying the changes in an item. In one example of differential decoding, copies of previously received packets are stored, together with a code indicating the file version to which they apply. Only packets to the parts of the file updated in a newer version need to be downloaded and the old packets can be reused. Alternatively or additionally, the file itself is used as a partial solution for recovering data from received packets, thus reducing the number of packets to be decoded. This method can be used, for example, when a FEC is used, of the type where each packet is a XOR of a plurality of packets. The version number of such a packet is the newest version number of any block used for the packet. During reconstruction, a set of equations linking together blocks and packets is solved. The old data may be used to assist such solution.

Two particular examples of such a slowly changing channel is the Internet WWW page of CNN (which is widely viewed) and the CNN daily continuous newscast. In addition to the changes caused by the change in news, some changes may occur as result of the personalization of the channel to a particular user and/or as a result of a request made by the user. By sending the channel using the methods described above, two advantages can be achieved. First, a short delay for retrieving most of the relevant channel is achieved, using a relatively low bandwidth. Thus, only the differences for particular viewers need to be sent. These differences can be sent, for example, by broadcast or by unicast (in Internet) or as data packets (in television) to be reconstructed by the receiver for the particular viewer. Alternatively or additionally, differential decoding can be used to allow a receiver to receive only a small number of packets and use these packets to display the personalized/changed page.

In one application, such a multicasting of WWW pages is used, together with a controller that receives responses from users, as a means for supporting an HTTP protocol using multicasting.

In an exemplary embodiment of the invention, the above method is used to encode streaming data as it is received. As a data stream is received from its source (e.g., a camera), it

is encoded into packets. As the stream lengthens in time, packets from some blocks are repeated. As indicated above, packet immediately before entry pints are preferably repeated more often and/or are made shorter. As the stream continues to grow, the transmission rate for all stream parts can be updated to reflect a desired reception and/or expected delay behavior.

A particular receiver may be viewing a rerun of the event, after many other viewers have viewed it. In an exemplary embodiment of the invention, the packet transmission probabilities are adapted to take into account sections where entry may be desirable and/or sections where a play-back function is desirable. These sections may be selected by an operator and/or automatically responsive to requests from viewers.

In some network types, instead of using a single transmitter, a plurality of transmitters may be provided, for example in different parts of the network, with each transmitter multicasting a different part of the file. Such a geographical dispersion may reduce bottlenecks in the network.

The present invention has been described using non-limiting detailed descriptions of embodiments thereof that are provided by way of example and are not intended to limit the scope of the invention. It should be understood that features and/or steps described with respect to one embodiment may be used with other embodiments and that not all embodiments of the invention have all of the features and/or steps shown in a particular figure or described with respect to one of the embodiments. Variations of embodiments described will occur to persons of the art.

It is noted that some of the above described embodiments may describe the best mode contemplated by the inventors and therefore include structure, acts or details of structures and acts that may not be essential to the invention and which are described as examples. Structure and acts described herein are replaceable by equivalents which perform the same function, even if the structure or acts are different, as known in the art. Therefore, the scope of the invention is limited only by the elements and limitations as used in the claims. When used in the following claims, the terms "comprise", "include", "have" and their conjugates mean "including but not limited to".

CLAIMS

1. A method of transmitting a data over a communication medium, comprising:
determining relative desired reconstruction times for different parts of the file;
differentially allocating different transmission rates for the different parts of the base responsive to said determining; and
transmitting the file in sections, at said different transmission rates.

2. A method according to claim 1, wherein said determining comprises determining a continuous of times representing a continuous play-back of said file.

3. A method according to any of claims 1-2, wherein said transmitting comprises multicasting.

4. A method according to any of claims 1-3, wherein said transmitting comprises transmitting different sections using different transmission channels.

5. A method according to any of claims 1-4, wherein said transmitting comprises said different sections at different packet transmission rates.

6. A method according to any of claims 1-5, wherein said sections are different sizes.

7. A method according to any of claims 1-5, wherein said different transmission rates are selected such that a receiver can reconstruct and play one section in the time it takes the receiver to receive a next section.

8. A method according to any of claims 1-7, wherein said file comprises a media file in an on-demand system.

9. A method according to any of claims 1-8, wherein transmitting comprises encoding said sections using an FEC (forward error correction) code having the property that a data section can be reconstructed from substantially any N packets received that relate to that data section.

For the applicant,

Fenster & Co. Patent Attorneys Ltd.
c: 212/01711

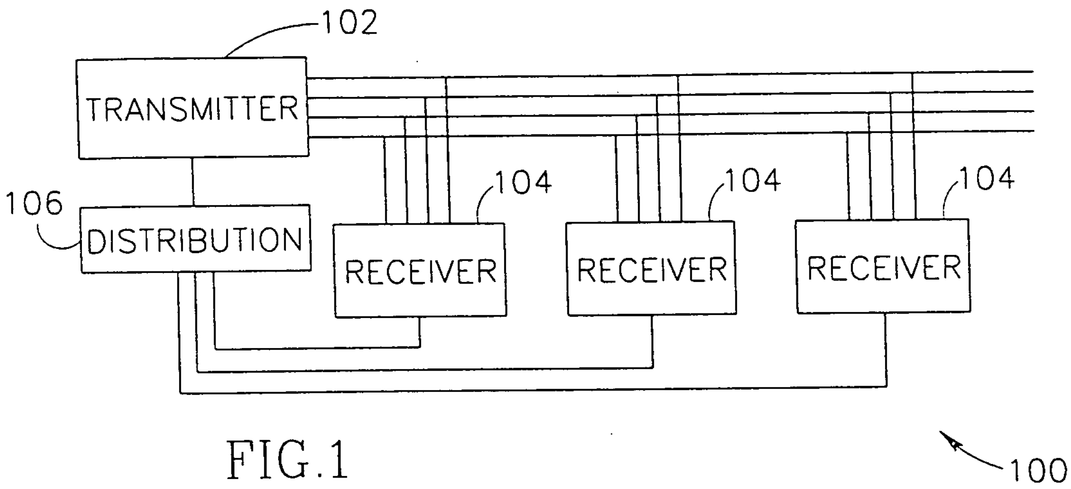

FIG.1

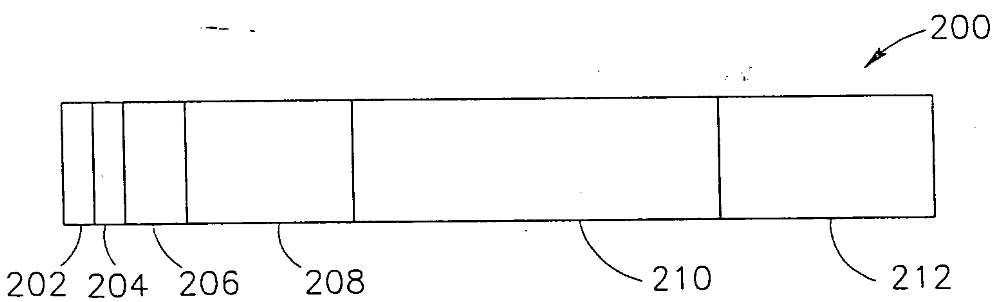

FIG.2

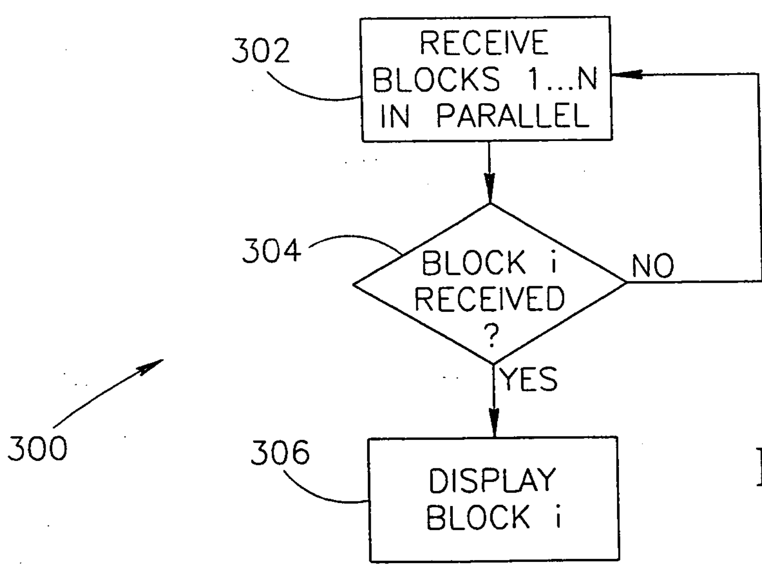

FIG.3